Fukushima Nuclear Accident

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What Happened

The nuclear disaster in the Fukushima plants in Japan serve as a beacon of what exactly can go wrong given the right circumstances. The earthquake that hit off the coast of Sendai on March 11th 2011, with a magnitude of 9.0 sent the entire island of Japan east a few meters. An earthquake of this magnitude triggered a 15 meter high tsunami wreaking havoc on the Fukushima reactors. The initial problem caused by the actual earthquake was disabling the power grid that normally pumps water into the reactors, keeping them cool. The subsequent tsunami then flooded auxiliary water pumps and systems leaving the engineers scrambling to find some way to keep the reactors cool. Old standards brought about in the 1960s were quickly crippled by the severity of the tsunami, leaving backup systems under several meters of water before responders were able to evacuate the water. The chaos brought about by multiple failures, made it so the government had to force evacuation in a 20 km radius around the effected reactors, evacuating some 160,000 people.

Why it is Still Important

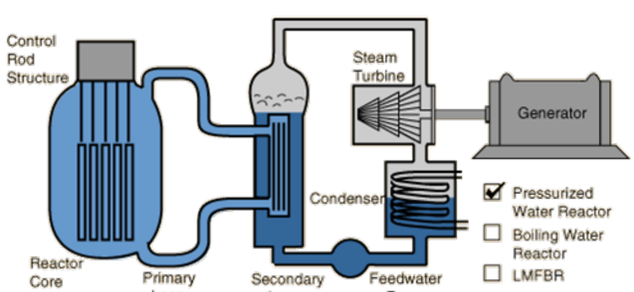
The evacuation was prompted in response to the potential exposure risk from the damaged reactors and the largely inoperable radiation monitoring around the site. Following evacuation, the focus turned toward exposure, the exposure rate was high for emergency responders and workers on site, topping out at over 250mSv*. The entirety of the 19,594 people that worked on site from the time of the disaster to December 31st 2011 only 167 workers had been exposed to significant radiation and still there were no reports of radiation sickness. Furthermore, off site, there is significant but non-threatening ambient levels of radiation from 0.06mSv/day in Fukushima City (65km away) to a high rate of 0.84mSv/day in Namie (24km away and within the 30km evacuation radius). In general, the people within the affected area will be exposed to almost 50 times less radiation than the 100mSv the responders had to endure. These facts, and given the nature of the most released radionuclides (ioidine-131 with a 8 day half-life, caesium-137 with a 30 year half-life and Cs-134 with a two year half-life) the bulk of the released radiation will continue to dissipate to safer levels in the coming years.

*Sv refers to the SI unit for equivalent radiation dose

How We Can Prevent Another Disaster

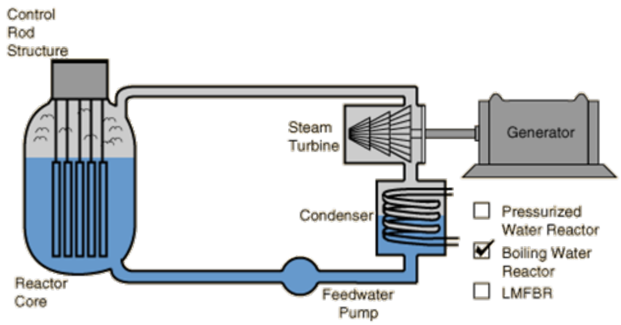
The disaster was largely effected by the lack of updated equipment. The Fukushima nuclear reactors are all “boiling-water” style reactors. Boiling-water reactors are a really old design and need to be updated to more modern and safer designs. The Fukushima nuclear power plant has been in use for more than 40 years, with most of its equipment in need of an updated. The first reactor on the Fukushima site needed to be retired in 2011, but the Japanese insist on running it until 2031. On top of the aging design and equipment, the Fukushima nuclear power plant was built near a major fault line, thus earthquakes are common around that area. The reactor requires sea water to cool it down, so naturally it was built near the sea, but in the case of an earthquake along the fault line, there is a high possibility the earthquake would create a tsunami, which can and did damage the reactors badly.

This disaster could have been largely avoided if technological concerns had been addressed before a natural disaster came and wiped out all the safeties in place meant specifically to prevent this kind of failure. A suggested replacement would be to use a “pressurized-water” reactor in power plants nearest to the public. In the pressurized water reactor (PWR), the water which passes over the reactor core to act as moderator and coolant does not flow to the turbine, but is contained in a pressurized primary loop. The primary loop water produces steam in the secondary loop which drives the turbine (Fig 1). The obvious advantage to this is that a fuel leak in the core would not pass any radioactive contaminants to the turbine and condenser, making the reactor run safer and more environmental friendly.



(Fig 1)

The old style reactor, the “boiling water” reactor, is still in use in many nuclear reactors today largely because it is simple to use. In the boiling water reactor (BWR), the water which passes over the reactor core acts as moderator and coolant while also being the steam source for the turbine (Fig 2). The disadvantage of this is that any fuel leak might contaminate the water, making it radioactive and allowing the radioactivity to reach the turbine and the rest of the loop. This flaw in the design makes for easy contamination if the reactor were to leak, leaving radionuclides free to escape.



(Fig 2)

Newer designs for nuclear power plants normally have at least three protection shields, which are the reactor fuel element cladding, pressure shell, and nuclear safety shell. Nuclear safety shield was typically built by concrete, but because Fukushima nuclear power plant was designed in 1960s, and hardly modern so its safety shield was built out of metal and plastic. Even in 1979, the Three Mile Island nuclear power plant disaster accident was prevented by the concrete safety shield and only three people were infected with radiation sickness.

Furthermore, location choosing is very important to maintaining a level of safety in the event of everything that could possibly go wrong, did go wrong. The location of nuclear power plants should try and be far away from the fault lines because in the event of an earthquake it is entirely possible that major damage could happen to the reactors. Also the population that lives around it should be very small, that way in the event of a disaster it would have a small impact on the general public.

Conclusion

In conclusion, the disaster in Fukushima was largely an exercise in why we as engineers should always be conscious of ever changing safety standards for every project where we are working. If the reactors had been brought up to even 2002 standards, the backup diesel pumps would have been in a sealed concrete box and unaffected by the rise in sea level. If the boiling water reactor had been converted to a newer and safer pressurized water reactor, then there might not have been any radiation leak and thousands would not be displaced from their homes.

Work Cited

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